

CHAPTER IV

SOURCE DEVELOPMENT

In selecting a source of water to be developed, the design engineer must determine that an adequate quantity of water exists for which a vested water right or permit to appropriate can be lawfully obtained and that the treated water delivered to the consumers will meet KDHE's PWS quality standards.

A. QUANTITY REQUIREMENTS

The quantity of water at the source shall be adequate to meet the projected maximum daily demand for the design period. Rights to the water must be obtained from DWR, which administers the Kansas Water Appropriation Act. A potential water user must make application to DWR to begin the process necessary to establish a water right (KWO, 2001). The time period for processing an application for a permit by DWR may be substantial. A processing time period of one year or more is not unusual. Assistance in completing an application can be obtained from any of the DWR field offices. The DWR considers a water use projection for twenty years reasonable for determining the requested quantity of water on an application to appropriate for municipal water supply use.

It is illegal for a PWSS in Kansas to use water without holding a vested right or applying for and receiving a permit to appropriate water. Also, it is important to recognize that some parts of Kansas have no water available for new permits. In those areas, acquisition of an existing water right and obtaining approval to change one or more of the water right's features may be the only way to meet future water needs. Features associated with an existing water right that must not be changed without DWR approval include the type of water use, the point of diversion (e.g., location of intake structure in a reservoir, stream, or river), or the place of water use. An acceptable meter must be installed on each diversion works in accordance with DWR's specifications, maintained in a satisfactory condition and used to provide the water usage information that is required to be in the annual water use report.

Yield restrictions for the various water resources are as follows:

1. FLOWING SOURCES – Where water is drawn from a flowing stream, river, or spring, DWR flow records should confirm its availability to meet the maximum daily demand for the design period during a 50-year drought with all prior water rights considered. The occurrence of a 100-year flood should not impair the proposed PWSS facilities.

2. IMPOUNDMENTS – Reservoirs and lakes used for PWS must meet the drought and flood restrictions of flowing streams. The effective storage needed to provide the firm yield shall take into account evaporation, seepage, and siltation losses. KWO handles requests for water from federal reservoirs through their water marketing program. As required by KSA 82a-301, DWR must approve all plans for construction of dams that impound more than 50 acre-ft (62,000 m³).
3. WELLS – Proposed well installations should be based on pumping test and/or historical records of withdrawal where available. Rights for withdrawal of groundwater must be obtained from DWR following a procedure similar to that for surface waters (KWO, 2001). DWR is assisted by Groundwater Management Districts in western and south central Kansas. Together they work to formulate and enforce local policies concerning the conservation, management, and control of water within each district.

B. QUALITY REQUIREMENTS

The quality of the proposed water resource should be determined for both average and extreme conditions of flow and climate. Major sources of historical water quality data are the Kansas Water Data Base and STORET maintained by KDHE and USEPA, respectively. In addition, KDHE requires that current water quality test results be submitted with permit applications for new sources (Appendix B). The quality of a particular water resource must be compared with PWS water quality and treatment requirements to determine the most cost effective treatment for a specific water resource. Current PWS water quality requirements are contained in KAR 28-15a, "Primary Drinking Water Regulations." Additional treatment requirements are specified in KAR 28-15-19, "Disinfection of drinking water." The designer must consider the worst conditions that may exist during the life of the facility.

C. SURFACE WATER – RESOURCE FACILITIES AND OTHER REQUIREMENTS

Surface water includes streams, rivers, impoundments, reservoirs, or other natural or man-made surface water sources. It can also include GWUI from a regulatory standpoint (Chapter V, Section M on Disinfection). In this discussion, springs are considered surface water sources while all types of wells are considered groundwater sources even though they may be regulated as GWUI.

1. FLOWING SOURCES

- a. STREAMS AND RIVERS – In selecting a location consider the effects of confluent streams, navigation requirements, water depth, trash, ice, 100-year flood level, water velocity, channel changes due to sand mining or silting, eutrophication, distances of separation from pollution sources, the possibility of shoal or bar formation, water quality and the effects of changing meteorological conditions on water quality, and access. Also evaluate quantity of supply, cost of development versus alternate locations and

sources, and possible need for an impounding reservoir, either in-channel or off-channel.

- b. SPRINGS – Springs will be approved only after an extensive sanitary survey has been completed. The requirements for the protection of the spring will be determined by KDHE. Minimal requirements for springs include:

- 1) Documentation must be provided to confirm the absence of pollution sources. Either ownership or a perpetual easement must be obtained by the owner of the spring for the land within 100 ft. (30.5 m) measured horizontally outward from the spring. In either case, positive assurance is to be provided that no septic tanks, wastewater facilities, sanitary sewers, force main, or tile absorption fields will be allowed within that area.

The owner may use the land for agricultural or pasture purposes except that livestock must be kept at least 100 ft. (30.5 m) away from the spring. Use of the land for any purpose shall not significantly contribute to pollution of the source water. Sanitary sewers to serve residential areas outside the 100 ft. (30.5 m) wide protected zone shall transport the wastewater, either treated or untreated, to either a point downstream from the spring or to a separate watershed.

If the land in question is owned by someone other than the owner of the PWSS, then a copy of a perpetual easement, detailing any limits or constraints on the use of the land by either party and showing the stamp of the Register of Deeds, must be submitted to KDHE. If the land is owned by the PWSS, then they must provide a letter to KDHE that acknowledges the ownership. Where the land in question is owned by the PWSS and other owners, the ownership letter and perpetual easements must be submitted to KDHE for the appropriate areas of land. In all cases, the documents must indicate that no potential sources of pollution will be allowed within 100 ft. (30.5 m) of the spring.

- 2) Springs located on a hillside or at the foot of a hill shall be avoided where sources of pollution are present on the slope above and within 300 ft. (91.4 m) horizontally of the spring. An adequate intercepting ditch shall be constructed and maintained so as to keep hillside storm water at least 100 ft. (30.5 m), measured horizontally, away from the spring.
- 3) Flood waters shall not approach closer than 100 ft. (30.5 m) to prevent contamination of the spring.

- 4) Proper drainage in the vicinity of the spring shall be provided so as to prevent the accumulation of surface water, either by runoff or backflow, to within 100 ft. (30.5 m) of the spring.
- 5) The intake structure and any pumping or water treatment facilities shall be enclosed in shelters which are weather and vandal resistant.
- 6) All water from springs shall be subjected to continuous disinfection and filtration as minimum treatment (Chapter V, Section M on Disinfection).
- 7) The spring area must be fenced to prevent unauthorized entry.

2. IMPOUNDMENTS

- a. **SITE SELECTION** – Consider topography, catchment area, potential pollution sources, nutrient sources, watershed management, storage capacity versus dam and spillway required, geology, safety, and water rights. The State Conservation Commission administers several programs dealing with watersheds and water resources which involve sources of funding for water supply development and improvement. A Kansas Water Resources Research Institute study reviewed the impact of watershed management practices on the use of multipurpose reservoirs and lakes (Randtke *et al.*, 1985).
- b. **RAW WATER CHARACTERISTICS** – Water quality variations for all conditions of stream flow should be considered.
- c. **PERMITS** – A permit for controlling stream flow, placing a structure on the bed of any stream, or approval of a dam or spillway design must be obtained from DWR. The requirements established by DWR are summarized in KSA 82a-301 through 305a, KAR 5-40-1 through 106 and KAR 5-42-5 (DWR, 2007).
- d. **LAKE USE** – The designation of a lake as single purpose or multi-purpose will be made by the owners of the lake. The State Conservation Commission administers the Multipurpose Small Lakes Program for small flood control, water supply, and/or recreational projects (State Conservation Commission, 2002). Recreational activities conducted in or on any water utilized as a source of water supply for a public water supply system must be conducted in such a manner that the water quality of the water will not be adversely affected by such activities. Swimming is not recommended in any water supply impoundment except at designated sites.

3. SINGLE PURPOSE LAKES – The following requirements must be met for single-purpose water supply lakes.

- a. Site preparation for the lake shall include removal of trees and brush to the conservation pool elevation without major disturbance of the original ground surface.
- b. Either ownership or a perpetual easement must be obtained by the owner of the lake for the land within 200 ft. (61 m) measured horizontally outward from the high water level elevation according to the same procedures cited for springs in this chapter. In either case, positive assurance is to be provided that no septic tanks, wastewater facilities, sanitary sewers, force mains, or tile absorption fields will be allowed within that area.

The owner may use the land for agricultural or pasture purposes except the livestock must be kept at least 15 ft. (4.6 m) away from the high water level elevation by fencing. Use of the land for any purpose shall not significantly contribute to pollution of the source water. Sanitary sewers to serve residential areas outside the 200 ft. (61 m) wide protected zone shall transport the wastewater, either treated or untreated, to either a point downstream from the lake or to a separate watershed. In all cases, the documents must indicate that no potential sources of pollution will be allowed within 200 ft. (61 m) of the lake.

- c. There shall be no upstream or direct discharges of untreated wastewater into the lake. Treated wastewater discharges must be approved by KDHE.
- d. A program to control algal growths and minimize taste and odor in the raw and/or treated water shall be carried out by the lake owner. KDHE has published a report relating taste and odor potentials in Kansas lakes to their trophic levels (Arruda and Fromm, 1988a).
- e. The owner shall carry out a program for maintenance of shorelines and control of aquatic weeds. It may be necessary at some time to lower the level of water in the lake to remove weeds and accumulated silt.
- f. Other than rock placed along bank lines for protection from erosion, no debris, trash, brush, fish habitat enhancement structures, or other solid materials may be placed in the lake for any purpose.
- g. During the planning process, the consulting engineer shall evaluate the watershed area for potential pollutant or nutrient contribution and project the effect that it may have on the eutrophication rate and water quality. Where the effect can be interpreted as contributing to taste and odor, drinking water quality standard violations, or DBP or turbidity problems, special attention to additional management of the lake watershed or to design of the treatment process will be required. KDHE and Kansas Water Resources Research Institute reports review the impact watershed pollutants have on

trihalomethane formation potential (Randtke *et al.*, 1987)(Arruda and Fromm, 1988b).

4. MULTIPURPOSE LAKES – For multipurpose lakes used primarily for public water supply purposes, the same requirements will apply as for single purpose lakes with the following exceptions:
 - a. Trees and brush may be left standing in the conservation pool area. These locations and the extent to which they may be covered by trees and brush shall be reviewed and approved by KDHE after consultation with KDWP on a case-by-case basis.
 - b. Artificial fish enhancement substrates may be utilized. The location, type and size of the area that may be covered by such substrates shall be reviewed and approved by KDHE.
 - c. Treatment of a lake surface to control algae is recommended rather than required.
5. INTAKE STRUCTURES – Intake designs for streams, rivers, lakes, and reservoirs or other natural or manmade surface water sources shall be approved by KDHE. Approval by the US Army Corps of Engineers or Bureau of Reclamation is also required for federal reservoirs. Listed below are requirements for intake structures.
 - a. Provide reliable and sufficient capacity to supply treatment plant flow requirements for a 20 to 40 year design period under minimum head conditions.
 - b. Locate intakes to avoid damage to aquatic life, excessive siltation or bank erosion, and runoff from sloughs and swamps. Protection against surges, ice, floods, floating debris, boats, and barges shall also be provided.
 - c. A floating log boom or other effective device should be used around the intake structure. Screens and grates should be used to protect pumps and treatment facilities and to minimize the intake of debris and aquatic life. Screens and grates should also be self-cleaning.
 - d. Inlet flow velocities of 0.25 to 0.5 ft/sec (0.08 to 0.15 m/s) will minimize frazil ice problems. Other control methods include injection of steam into pump suction, backflushing with settled water, use of air bubbler systems in front of gate openings, and locating the intake in still water.
 - e. Inlets or ports shall be located so that water may be admitted from a choice of depths to take advantage of favorable water quality. Their locations should be easily identified through permanent markers on the intake structures. A

choice of at least three depths should be provided. Withdrawal of water from more than one level is desirable in run-of-the-stream intakes if the water quality varies with depth.

The lowest inlet or gate port should be placed at the elevation where it will be entirely submerged at all water stages yet not too close to the stream bottom where a high sediment load may be encountered. Exposed or slightly submerged inlets should be avoided where potential navigational hazards exist. The lowest inlet location in a flowing source, lake or reservoir should consider future silt accumulations. Flowing source inlets may also be affected by channel changes caused by meandering, scouring or sand mining.

In general, the velocity through the gross area of the inlets or ports should not exceed 1.0 ft/sec (0.3 m/s). Removable racks with 0.5 to 0.75 inch (12.7 to 19.1 mm) diameter metal bars to provide 1 to 3 inch (25.4 to 76.2 mm) openings and velocities not to exceed 2 ft/sec (0.6 m/s) at maximum design flow through the openings should be used at the intake ports. Where ice accumulation may occur, a velocity of less than 0.5 ft/sec through the net area of the rack is recommended. Smaller debris can be removed using screens with 0.375 inch (9.5 mm) or smaller openings and velocities similar to those for racks.

- f. Inspection manholes should be located every 1000 ft. (305 m) for pipe sizes large enough to permit visual inspection and for occasional cleaning of the inlet line. Conduit velocities should be 3 to 4 ft/sec (0.9 to 1.2 m/s) to avoid deposition of solids. Straight lines on a rising or falling grade should be used to avoid the accumulation of air. If this is not possible, provisions to release accumulated air must be provided at the high points in the inlet line.
- g. Shore shafts or pump wet wells should provide storage for intake water at the design flow and minimum head conditions, adequate pump submergence, and surge capacity in the event of power failure. Fixed and traveling screens can be located in the shore shaft. Motors and electrical controls should be located above grade and protected from flooding. Shore shafts should be accessible, designed against flotation, provided with chemical addition points if necessary, and fitted, where practical, with valves for cleaning, leak testing, and backflushing.
- h. Provisions to preclude unauthorized access shall be included in the design of the intake structure.
- i. Where it is deemed necessary, practices to control zebra mussels or other aquatic nuisances must be implemented. Specific methods to control aquatic nuisances must be approved by KDHE prior to their implementation.

6. OFF-CHANNEL RESERVOIRS – These are facilities into which water is diverted during periods of high stream flow for future release to treatment facilities (or for low flow augmentation). Off-channel reservoirs shall be constructed to assure that the water quality is protected by controlling runoff into the reservoir, dikes are structurally sound and protected against wind action and erosion, and the point of influent flow is separated from the point of withdrawal.

D. GROUNDWATER – RESOURCE FACILITIES AND OTHER REQUIREMENTS

Groundwater sources include water from drilled, bored, or driven wells and infiltration lines, not under the direct influence of surface water. Drilled wells are preferred. Springs are considered surface water sources (Section C). Sources most likely to be under the direct influence of surface water (GWUI) include infiltration lines, horizontal collector wells, and shallow wells with screen openings less than 50 ft. (15 m) deep and located within 200 ft. (61 m) of surface water. Under the SWTR, all GWUI must be treated like surface water (Chapter V, Section M on Disinfection).

All water obtained from wells shall be disinfected and filtration employed where needed (Chapter V, Section M on Disinfection). The extent of water treatment required will be determined on the basis of geological data, well construction features, nearby sources of contamination, laboratory analyses, and MCLs. When a well draws water from creviced limestone strata and it is evident that the limestone supply is contaminated, the use of that supply cannot be considered appropriate unless the water is properly treated, in part by clarification and filtration, to eliminate harmful contaminants.

1. SANITARY SURVEYS – By means of a sanitary survey, the PWSS evaluates the potential threats to a proposed well presented by nearby sources of contamination. This allows the PWSS to estimate costs to reduce or contain threats to the proposed well by contaminant sources identified in the survey. Sanitary surveys made for selection of locations for wells should consider the following items:
 - a. Character of local geology, size and topography of catchment area, and slope of ground surface, as such factors relate to the potential transport of contaminants toward the well.
 - b. Nature of soil and underlying porous strata whether clay, sand, gravel, or rock (especially porous limestone); and coarseness of sand or gravel, thickness of water bearing stratum, depth to water table, and location and log of wells in the vicinity that are in use and/or abandoned, as such factors relate to the potential transport of contaminants towards the well. Geologic data should be obtained for new wells at 5 ft. (1.5 m) intervals and at each pronounced change in formation along with other pertinent well drilling information. KGS maintains a Well Sample Library in Wichita.

- c. Slope of water table, as determined from observation wells, preferably, or from studies of wells in the area.
 - d. Extent of drainage area likely to contribute water and potential contaminants to the supply, population of drainage area, and waste disposal methods employed in the drainage area.
 - e. Susceptibility of the proposed well location to flooding from nearby surface waters as indicated by the boundaries of flood plain delineations or historical high water elevations.
 - f. Nature, distance, and direction of potential local sources of pollution such as animal feedlot operations, sanitary landfills, seepage pits, cesspools, septic tank lateral fields, privies, sink holes, salt or brine supplies, test holes, abandoned wells, borings, and chemical manufacturing, handling, and storage facilities, including underground storage tanks, pipelines for industrial products, and industrial lagoons.
 - g. Special care should be taken to determine nitrate sources in the proposed well's recharge area and to evaluate fully the nitrate concentration in the aquifer in which the well will be completed. In addition to nitrate sampling of test holes in the immediate vicinity of the proposed public water supply well, other sources of information that should be considered include data from irrigation wells or other water supply wells in the general vicinity, KGS bulletins assessing the geology and hydrology of the region, and data from the KDHE Groundwater Quality Monitoring Network. The nitrate level in the aquifer in which the well will be completed should be significantly less than the current nitrate MCL unless blending with other low nitrate water or treatment for nitrate removal will be provided.
 - h. The SWA conducted for the PWSS under SWAP shall be reviewed as part of the sanitary survey when determining the sources of real or potential contamination. The SWA shall be updated as is necessary based on the findings of the sanitary survey.
2. LOCATION AND PROTECTION OF WELLS – Groundwater sources shall be located, constructed, and maintained in a manner which will assure minimal possibility of contamination and be so situated and developed as to prevent surface water from entering the well. During the installation of the well, the contractor shall provide protection to prevent tampering or accidental entrance of foreign materials. The following are specific siting limitations for new wells.
- a. There must be an absence of pollution sources within 100 ft. (30.5 m) of the well. Documentation must be provided to confirm the absence of such sources. Either ownership or a perpetual easement must be obtained by the

owner of the well for the land within 100 ft. (30.5 m) measured horizontally outward from the well center. In either case, positive assurance is to be provided that no septic tanks, wastewater facilities, sanitary sewers, force mains, or tile absorption fields will be allowed within that area.

The owner may use the land for agricultural or pasture purposes except that livestock must be kept at least 100 ft. (30.5 m) away from the well. Use of the land for any purpose shall not significantly contribute to pollution of the source water. Sanitary sewers to serve residential areas outside the 100 ft. (30.5 m) wide protected zone shall transport the wastewater, either treated or untreated, to either a point downstream from the well or to a separate watershed.

If the land in question is owned by someone other than the owner of the PWSS, then a copy of a perpetual easement, detailing any limits or constraints on the use of the land by either party and showing the stamp of the Register of Deeds, must be submitted to KDHE. If the land is owned by the PWSS, then they must provide a letter to KDHE which acknowledges the ownership. Where the land in question is owned by the PWSS and other owners, the ownership letter and perpetual easements must be submitted to KDHE for the appropriate areas of land. In all cases, the documents must indicate that no potential sources of pollution will be allowed within 100 ft. (30.5 m) of the well.

- b. Proper drainage in the vicinity of the well shall be provided so as to prevent the accumulation of surface water, either by runoff or backflow, to within 100 ft. (30.5 m) of the well.
- c. Wells located on a hillside or at the foot of a hill shall be avoided where sources of pollution are present on the slope above and within 300 ft. (91.4 m) horizontally of the well. An adequate intercepting ditch shall be constructed and maintained so as to keep hillside storm water at least 100 ft. (30.5 m), measured horizontally, away from the well.
- d. The well shall not be located in a ravine where surface water flows may be obstructed or concentrated.
- e. Shallow wells with screen openings less than 50 ft. (15 m) deep shall not be located within 200 ft. (61 m) of a surface water unless treatment will be provided that fully complies with all requirements applicable to groundwater sources under the influence of surface water (Chapter V, Section M on Disinfection). On a case-by-case basis, KDHE may approve the installation of such a well without the necessity of providing such treatment, upon submittal of a report by a qualified professional establishing that, under the

particular hydrogeologic conditions, the proposed well will not be under the direct influence of any surface water.

- f. The well vent on a pitless unit or a vent in a well house or on a platform must be located at least 2 ft. (0.6 m) above the 100-year flood level to prevent contamination by flood waters. If this level is not known, then the required elevation is at least 2 ft. (0.6 m) above the highest known flood level.
- g. A wellhead protection plan for continued protection of the wellhead from potential sources of contamination shall be provided as determined by KDHE. The PWSS's sanitary survey and SWA should be reviewed as part of developing a wellhead protection plan.
- h. Additional provisions such as fencing also may be necessary to ensure the protection of the wellhead.

3. CONSTRUCTION CRITERIA FOR WELLS – The following criteria shall be followed in constructing a PWS well. Information about well abandonment is also presented. Additional design requirements for pumps and water lines are presented in Chapter VII, Pumping Facilities, and Chapter VIII, Distribution Systems.

- a. CONTRACTOR LICENSING – Any water well contractor involved in the construction or reconstruction of any public water supply well shall possess a valid water well contractor's license, issued by the KDHE under the provisions of KAR 28-30-3. All contractors shall submit to KDHE a completed water well record form WWC-5 upon construction or reconstruction of a public water supply well. A completed water well record form WWC-5P is to be submitted to KDHE when public water supply wells are plugged.
- b. DRILLING FLUIDS, ADDITIVES, AND PACKERS
 - 1) Drilling procedures or materials such as drilling fluids, additives, and packers shall not impart any taste and odor, toxic substances, bacterial contamination, or any regulated water quality contaminant to the well installation or the aquifer itself.
 - 2) Water used for drilling fluids shall be from a fresh, clean source. Only drilling fluids that will not plug the aquifer should be used. Organic drilling fluids such as those formed through the addition of polymeric additives have the potential to enhance biological activity within the aquifer and are not approved for use.
 - 3) When drilling fluid additives are used, the properties of the drilling fluid shall be maintained within those limits that will allow for the

complete removal of the additives from the well without adversely affecting hydraulic capacity, pumping efficiency, or water quality.

c. TEMPORARY SEALING REQUIREMENTS

- 1) During construction, a temporary means of sealing the well shall be provided to prevent debris or any type of contaminant from entering the well or the annular space.
- 2) Wells without an installed pump shall be securely sealed until the setting of the pump or the plugging of the well upon its abandonment.
- 3) A welded metal plate or a threaded cap is the preferred method for the temporary sealing of a well.

d. WELL CASING

- 1) All wells shall have durable watertight casing from at least 1 ft. (0.3 m) above finished ground surface to the top of the producing zone of the aquifer. The casing shall extend at least 20 ft. (6.1 m) below the ground surface.
- 2) All casing material shall be new and conform to the types, manufacturing standards, and minimum diameter requirements specified in AWWA Standard A100. Minimum wall thickness requirements for steel well casing shall conform to AWWA Standard A100. Minimum wall thickness requirements for thermoplastic well casing shall conform to ASTM F480.
- 3) Joints should be watertight and of the type specified in AWWA Standard A100.
- 4) The casing shall extend not less than 12 inches (0.30 m) above the top of the well house floor. No casing shall be cut off below the ground surface except to install a pitless unit.
- 5) The casing should be provided with sufficient guides welded to the casing to permit unobstructed flow and uniform thickness of grout.
- 6) The top of the well casing shall be sealed by installing a sanitary well seal.

e. WELL SCREEN

- 1) The well screen serves as the intake section of a water supply well, allowing the passage of water from an aquifer in unconsolidated formations such as sand and gravel. The screen also provides structural support for the surrounding formation. The screen should be designed to promote the free flow of water into the well pump area while preventing the entrance of sand.
- 2) The screen aperture size should be designed to retain a certain specified percentage of the formation material for naturally developed wells or gravel-pack material for gravel-packed wells as determined by accepted well design practices and site specific conditions.
- 3) The entrance velocity into the screen should not exceed 0.1 ft/sec (0.03 m/s) based on the maximum anticipated well flow rate or yield as determined by the following formula:

$$V_e = \frac{Q}{7.48 * A_e * L}$$

where,

- V_e = entrance velocity (ft/ min)
 Q = maximum well flow rate or yield (gpm)
 A_e = effective aperture area per foot of screen (ft²/ft)
(The effective aperture area shall be taken as one half of the total aperture area per foot of screen to allow for clogging of slots.)
 L = length of screen (ft)

KDHE will approve entrance velocities that exceed the 0.1 ft/sec (0.03 m/s) limit upon a showing that higher velocities will not impair the integrity of the well screen or result in excessive head loss.

- 4) Screen length should be determined by the thickness and hydrologic character of the aquifer, in conjunction with the determination of screen aperture size.
- 5) In some applications, other considerations such as approach velocities, turbulent versus laminar flow, and velocity distributions across the screen and through the aquifer, may require variance from the above screen design criteria.

- 6) The material from which the screen is fabricated shall be corrosion resistant and not susceptible to damage by chemical action of groundwater or cleaning operations.
- 7) Joints between screen sections and blank casing spacers should be welded or threaded, watertight, straight, and as strong as the screen.
- 8) Guides should be placed above and below all screen sections to hold the screen in the center of the borehole.

f. GRAVEL PACK

- 1) Gravel pack is installed in the annular space between the screen (and casing) and bore hole for the purpose of stabilizing the formation.
- 2) Gravel pack should consist of smooth, well rounded particles, at least 95 percent siliceous material with an average specific gravity of not less than 2.5. Before placement, the gravel pack should be washed and free of shale, mica, clay, dirt, loam, and organic impurities of any kind, and contain no iron or manganese in a form or quantity that will adversely affect the water quality.
- 3) Gravel pack design should be based on the ratio of the grain size of the gravel pack to the formation material and sized to stabilize the native formation and yet allow water to be produced from it as determined by accepted well design practices and site specific conditions. The gradation of the gravel pack should be selected after test hole samples of the formation material to be screened have been sieved and analyzed pursuant to ASTM C136.
- 4) The gravel pack should be placed in a continuous layer of material surrounding the entire screen without bridging or voids and should extend above the screen to a height sufficient to compensate for potential settlement of the gravel pack during well development. Placement of the gravel pack should also provide a sufficient buffer between the well intake and the annular seal above. The minimum thickness of gravel pack to allow for proper placement of the gravel pack in the annulus around the screen is 4 inches (10.2 cm).
- 5) Gravel pack shall be disinfected immediately prior to placement in the annulus of the well by immersing the gravel pack in a chlorine solution containing a final free available chlorine concentration of at least 200 mg/L. An acceptable chlorine solution may be prepared as described below in Subsection D.3.k.2.

- 6) The installation of gravel pack refill pipes is approved by KDHE where excessive loss of gravel pack is anticipated to occur due to formation conditions. Gravel pack refill pipes shall be Schedule 40 steel and located in the grouted annular opening of the well, surrounded by a minimum of 1.5 inches (3.8 cm) of grout. Gravel pack refill pipes shall be incorporated within the pump's concrete foundation, and extend at least 12 inches (0.3 m) above the pump house floor or concrete apron. To prevent contamination of the well, the gravel pack refill pipe shall be provided with a securable access lid or cap designed to completely cover the opening of the pipe and provide a watertight seal.

g. **GROUTING OF ANNULAR SPACE BETWEEN THE CASING AND DRILL HOLE**

- 1) Wells shall be sealed by grouting the annular space between the casing and the well bore from ground level to a minimum of 20 ft. (6.1 m) or to a minimum of 5 ft. (1.5 m) into the first clay or shale layer, if present, whichever is greater. If a pitless well unit is being installed, the grouting shall start below the junction of the pitless well unit where it attaches to the well casing and shall continue a minimum of 20 ft. (6.1 m) below this junction or to a minimum of 5 ft. (1.5 m) into the first clay or shale layer, if present, whichever is greater.
- 2) To facilitate grouting, the grouted interval of the well bore shall be drilled to a minimum diameter at least 3 inches (7.6 cm) greater than the maximum outside diameter of the well casing. If a pitless well unit is being installed on the well's casing, the well bore shall be a minimum diameter of at least 3 inches (7.6 cm) greater than the outside maximum diameter of the well casing through the grouted interval below the junction of the pitless well unit where it attaches to the well casing.
- 3) Protection from leakage of grout into the gravel pack or well screen shall be provided.
- 4) Waters from two or more separate aquifers shall be separated from each other in the bore hole by sealing the bore hole between the aquifers with grout or other material specifically approved by KDHE.
- 5) If a dummy casing is to be retained, the annular space between the dummy and the well casings shall be filled with grout having a minimum thickness of 1.5 inches (3.8 cm) to a minimum grout depth

of 20 ft. (6.1 m). In addition, the annular space between the dummy casing and well bore shall be grouted as specified in this chapter.

- 6) Sand-cement grout or neat cement grout shall be used for grouting the annular space from ground level to 20 ft. (6.1 m) below the surface, or, if a pitless well unit is being installed, from the junction of the pitless well unit with the well casing to 20 ft. (6.1 m) below the unit.
 - a) "Sand-cement grout" means a mixture consisting of one 94 lb (43 kg) bag of portland cement (ASTM C150) to an equal volume of sand having a diameter no larger than 0.080 inches (2 mm) to 5 to 6 gallons (19 to 23 L) of water.
 - b) "Neat cement grout" means a mixture consisting of one 94 lb (43 kg) bag of portland cement (ASTM C150) to 5 to 6 gallons (19 to 23 L) of water. A maximum of 5 percent, by weight, of bentonite may be added. Other additives may be used only with KDHE approval.
 - c) Water used to mix cement grout should be clean, fresh water, free of oil or other organic material, and with a total dissolved mineral content less than 2,000 parts per million. High sulfate water should be avoided.
 - d) Care should be exercised to control the heat of hydration during grouting where thermoplastic well casing has been installed. Additives that tend to significantly increase the heat of hydration are not recommended.
- 7) For PWS wells, KDHE does not recommend the use of annular seals consisting solely of bentonite clay grouts because of concern whether bentonite seals have sufficient shear strength to resist hydrostatic forces in certain aquifer systems. Bentonite clay grouts are approved for grouting the annular space in a well for depths greater than 20 ft. (6.1 m) from the surface or greater than 20 ft. (6.1 m) below the junction of a pitless well unit with the well casing, where the initial 20 ft. (6.1 m) length of annular space will be sealed with a sand-cement or neat cement grout.
 - a) "Bentonite clay grout" means a mixture consisting of water and commercial grouting sodium bentonite clay as per the manufacturer's recommendations to achieve a weight of not less than 9.4 lb (4.3 kg) of bentonite clay per gallon (3.8 L) of mix. Weighting agents may be added as per the manufacturer's recommendations.

- b) Sodium bentonite pellets, tablets, chips, or other granular forms of sodium bentonite are acceptable as an annular seal at depths greater than 20 ft. (6.1 m) provided the material can be installed without bridging or voids and it meets the 9.4 lb (4.3 kg) of bentonite clay per gallon (3.8 L) mix requirement.
- c) Sodium bentonite products that contain low solids, are designed for drilling purposes, or that contain organic polymers shall not be utilized for grouting the annular space of a well.

h. PLUMBNESS AND ALIGNMENT REQUIREMENTS

- 1) The completed well shall be sufficiently plumb and straight so that there will be no interference with the installation, alignment, operation, or future removal of a pump.
- 2) Every well should be tested for plumbness and alignment in accordance with AWWA standards.
- 3) The test method for plumbness and alignment and allowable tolerance shall be clearly stated in the construction specifications for the well.

i. DEVELOPMENT

- 1) Every well shall be developed to remove the native silts and clays, drilling mud, and the finer fraction of the gravel pack.
- 2) The construction specifications for the well shall provide for the application of appropriate well development techniques for the optimization of well efficiency and specific capacity. The specifications should further define criteria for determining satisfactory completion of well development. In general, development should continue until the optimum specific capacity is obtained from the completed well. Additional criteria for determining completion of well development may include a limit on sand content. If so, a method for measuring sand content should be specified.
- 3) Records of all development work should be maintained including measurements, at appropriate time intervals, of key parameters such as static and pumping water levels, production rates, specific capacity, sand content, specific conductance, temperature, etc.

- 4) Where chemical conditioning is required, the construction specifications for the well shall include provisions for the method, equipment, chemicals, testing for residual chemicals, and disposal of wastes, disinfectant solutions, and inhibitors.

j. WELL CAPACITY TESTS

- 1) Yield and drawdown tests shall be performed on every public water supply well prior to placement of the permanent pump in order to verify the pumping rate and the capability of the well and aquifer to maintain this production level. The test methods and data reporting requirements shall be clearly described in the construction specifications for the well.
- 2) Well capacity tests should be conducted only after development of the well has been completed satisfactorily.
- 3) During the tests, the discharge of the pump shall be conducted beyond the potential zone of influence of the well by pipeline or lined channel.
- 4) A constant-discharge test that consists of continuously pumping the supply well at a rate that is at least as high as the long-term production rate required of the well should be conducted. Water level measurements should be obtained before, during, and after the pumping test in order to determine the static water levels, to evaluate the effect of pumping, and to determine a profile of the recovery of the water level from the pumping state to the original, static level. The measurement frequency of water levels during pumping should be such that an adequate delineation of the time-drawdown relationship can be obtained. Additional well capacity tests such as a step drawdown tests are recommended.

k. DISINFECTION – KDHE procedures for disinfecting gravel-packed wells and completed wells, whether new, modified, or reconditioned, are as follows:

- 1) All drilling waters used during the construction or reconstruction of any water well shall be disinfected immediately prior to any drilling by thoroughly mixing with these waters enough sodium hypochlorite to produce a free available chlorine concentration of at least 200 mg/L. Mixing of additional sodium hypochlorite with drilling waters may be required to maintain a minimum free available chlorine concentration of at least 200 mg/L while drilling is in progress.

- 2) Gravel for gravel-packed wells shall be disinfected immediately prior to placement by immersing the gravel in a chlorine solution prepared using clean water having a final free available chlorine concentration of at least 200 mg/L. A satisfactory chlorine solution may be prepared by thoroughly dissolving approximately 5 oz (142 g) of high test calcium hypochlorite (65 percent available chlorine) in every 100 gallons (380 L) of water.
 - 3) Completed wells, after development, shall be disinfected by mixing with the water in the well enough of a pre-mixed calcium hypochlorite solution to produce a free available chlorine concentration in the well of at least 100 mg/L. This will require thoroughly dissolving in clean water approximately 1.5 lb (0.68 kg) of high test calcium hypochlorite (65 percent available chlorine) for each 1,000 gallons (3,800 L) of well volume that is occupied by water.
 - 4) Just prior to setting the pump, the pump and the pump column shall be washed down with a chlorine solution having an initial free available chlorine concentration of at least 200 mg/L. An acceptable chlorine solution may be prepared as described above in Subsection D.3.k.2.
- l. ABANDONED WELLS AND TEST HOLES – Before any well or test hole drilled in connection with a water supply is abandoned, it shall be plugged in such a manner as to prevent the pollution of the groundwater by contaminating substances. Abandoned water wells and test holes, whether cased or uncased, shall be plugged in accordance with the requirements of KAR 28-30-7.
- m. HORIZONTAL COLLECTOR WELLS
- 1) General – HCWs will generally be reviewed on the same basis as other PWS wells are reviewed except that a comprehensive siting study must be completed and a copy of the findings submitted to KDHE for review. Given their unique design, the review and approval of HCWs and their ancillary items will be on a case-by-case basis.
 - 2) Caisson
 - a) Construction joints and porthole assemblies shall be indicated.

- b) Wall shall be reinforced to withstand the forces to which it will be subjected.
- c) Caisson shall be continuously monitored for trueness to vertical during the forming, pouring and sinking processes.
- d) Caisson cutting shoe design shall be illustrated.
- e) Lateral collectors shall be in areas and at depths to maximize flow into the caisson.
- f) Lateral screen design shall permit maximum flow with minimal fouling.
- g) Lateral collectors shall be horizontal.
- h) Caisson opening shall be covered with a watertight floor.
- i) All openings in the floor shall be curbed and protected from the entrance of foreign material.
- j) Routing of pump discharge piping through the caisson walls will not be approved. However, where circumstances make this requirement infeasible, a watertight seal must be installed at the caisson wall.
- k) A monitoring and maintenance program for caisson laterals shall be developed and implemented to maximize the useful life of the HCW.

3) Ancillary Items

Pumping, treatment, water lines and related appurtenances shall be according to the requirements of Chapters V, VII, VIII and IX.

n. RECONSTRUCTED WELLS AND RELATED APPURTENANCES

- 1) Reconstructed wells and their related appurtenances must meet the requirements for PWS wells as stated in this chapter.
- 2) Original well construction drawings or well construction drawings based on field investigations when original well construction drawings do not exist must be part of the documentation submitted to KDHE for its review and approval.

- 3) Where well reconstruction includes the insertion of one or more casing/screen assemblies into an existing well, the required grout and gravel pack thicknesses stated in this chapter shall apply to all bore hole-to-casing and casing-to-casing annular spacing. Requirements for the construction of PWS wells pertaining to well casings as stated in this chapter shall apply to all casings.
 - 4) Requirements for PWS wells pertaining to water rights, wellhead protection, development, disinfection, etc. as stated or referenced in this chapter shall also apply.
4. CONSTRUCTION CRITERIA FOR WELL HOUSES, DISCHARGE PIPING, AND RELATED APPURTENANCES – The following criteria for the construction of well houses and for discharge piping and related appurtenances must be followed. Additional design requirements for pumps are presented in Chapter VII, Pumping Facilities.
- a. GENERAL WELL HOUSE REQUIREMENTS
 - 1) The well house shall be provided with a doorway and a door at least 2 ft. 8 inches (0.8 m) by 6 ft. 8 inches (2.0 m) which opens outward and extends to the floor. The door shall be equipped with a lock.
 - 2) Well houses located on hill slopes shall have not less than 50 percent of the floor area above ground level and the door located on that part of the floor above ground level.
 - 3) The well house walls and ceiling shall be insulated.
 - 4) Where necessary, additional protection against freezing shall be provided by installing a thermostatically controlled electric heater or other suitable type of heating unit.
 - b. WELL HOUSE FLOOR
 - 1) The well house floor elevation shall accommodate the well vent elevation requirement that the vent be located at least 2 ft. (0.6 m) above the 100-year flood level. If this level is not known, then the required vent elevation is at least 2 ft. (0.6 m) above the highest known flood level.
 - 2) The top of the floor slab shall not be less than 1.5 ft. (46 cm) above the natural ground.

- 3) The well house floor shall be constructed of reinforced, watertight concrete not less than 4 inches (10.2 cm) thick at any point.
- 4) The joint between the concrete base that supports the pump discharge head assembly and the floor shall be watertight. The concrete base that supports the pump discharge head assembly shall be extended to natural ground to provide solid support.
- 5) The floor shall extend not less than 3 ft. (0.9 m) in all directions from the outer edge of the drill hole.
- 6) The floor slab shall rest upon thoroughly compacted earth or upon a protected settled sand fill. Consideration should be given to the frost line prior to preparing the ground that will support the floor slab and the concrete base that will support the pump discharge head assembly.
- 7) The floor shall slope at a rate of 1/8 in/ft (1.0 cm/m) toward the floor drain.

c. FLOOR DRAIN

- 1) A minimum 4 inch diameter (10.2 cm) floor drain with a perforated or screened cover shall be provided.
- 2) The drain pipe shall carry the drain water to the ground surface at least 20 ft. (6.1 m) from the well or at least 4 ft. (1.2 m) from the well house wall at which point the pipe may be connected to other suitable 4 inch diameter (10.2 cm) pipe so that the drainage will be carried to the ground surface at least 20 ft. (6.1 m) from the well.
- 3) The drain pipe shall be laid on a grade of not less than 1/8 in/ft (1.0 cm/m) and shall discharge onto the surface of the ground. The drain shall not be connected to any storm drain, sanitary sewer, or any other closed conduit. The discharge end of the drain line should be covered with a coarse non-corrodible screen to prevent the entrance of small animals.

d. CASING SEAL AND DISCHARGE PIPING

- 1) The casing shall extend at least 1 inch (2.5 cm) up into the metal base plate of the pump discharge head assembly so as to form an overlapping seal. For pump discharge head assemblies that have a flat metal base plate or radial ribs that will interfere, a metal skirt projecting downward may be welded to the outside edge of the metal

base plate of the pump discharge head assembly to form a cover that will overlap the well casing.

- 2) The metal base plate of the pump discharge head assembly shall be grouted and bolted or otherwise securely sealed to the concrete base that supports the pump discharge head assembly so as to be watertight.
- 3) The discharge line, meter, and check and shutoff valves shall be located above the well house floor.

e. WELL VENT

- 1) The vent shall be constructed of metal tubing or pipe and fitted through the pump head's metal base plate so as to form a watertight connection with the base.
- 2) The vent shall terminate in a full 180° return bend not less than 2 ft. (0.6 m) above the pump base.
- 3) The opening in the vent shall be screened with 16-mesh non-corrodible screen.

f. WATER LEVEL MEASUREMENT

- 1) Provisions shall be made for the periodic measurement of water levels in the completed well in accordance with the requirements established by DWR in KAR 5-6-13 for water well level measurement (DWR, 1999). The following water level measurement methods are approved for public water supply wells:
 - a) Air line method;
 - b) Separate observation well within 25 ft. (7.6 m) of the production well; or
 - c) Electronic water level measurement sensors.

A separate tube installed outside the casing for use of a tapeline drawdown measurement is prohibited.

- 2) Air Line Method – The air line method measures depth to water level by determining the air pressure required to push water out of a submerged tube of known length. The air line tube shall be constructed of corrosion-resistant materials and pass down through

the pump head's metal base plate and into the well casing so as to be continuously within the inside diameter of the well casing in a manner that will provide for a watertight seal between the casing and the pump head's metal base plate, i.e., a watertight packing gland or equal shall be provided around the casing where it passes through the pump head's metal base plate. For wells with a submersible pump, the air line shall be continuously within the inner diameter of the well casing and sealed at the top of the well as described above to preclude contamination. To avoid turbulence near the intake of the pump, the lower end of the air line should be several feet above or below the point where water enters the pump but still extend below the lowest possible pumping level. The upper end of the tube shall be fitted with suitable connections for an air gauge, valve, and air pump. The actual installed length of air line shall be indicated on a pump head's metal base plate in the immediate vicinity of the well.

g. VALVES AND OTHER APPURTENANCES

- 1) Pump Discharge Line – The pump discharge line shall be equipped with a check valve, a shutoff valve, and a standard pressure gauge.
- 2) Air/vacuum Relief Valves – Combination air/vacuum relief valves may be required where air is forced into the pump discharge line through the pump resulting in decreased efficiency and possibility of surges within the lines. These valves are potential sources of contamination to the water supply because contaminants can be drawn into the water supply on the vacuum relief cycle.

The vent discharge lines from combination air/vacuum relief valves on pump discharge lines should terminate in a downward position about 2 ft. (0.6 m) above the floor of the well house. If splashing is a problem, a loose fitting "splash guard" may be used. The end of the vent discharge line should be screened with 16-mesh non-corrodible screen. In no case should the vent discharge line be tightly connected to the floor drain. Air/vacuum relief valves on pump discharge lines should be located on the pump side of the check valve and meter.

Where water hammer is problematic, combination air/vacuum relief valves with slow-closing devices or air-throttling devices incorporated into their valve design may be installed to minimize water hammer effects. Installation of such devices near the pump is critical to their effectiveness.

- 3) Meters – Meters shall be provided for all wells. Meters shall meet the requirements established by DWR in KAR 5-1-4 et seq. (DWR,

2004). Meters should be located on the pump discharge line and on the pump side of a shutoff valve but after the air/vacuum relief valve and check valve.

- 4) Sampling Taps – Sampling taps are required on the discharge side of a pump at locations both upstream and downstream from where chlorine (or any other treatment) is applied to the pump's discharge piping. The upstream sampling tap is for collecting untreated well water samples while the downstream sampling tap is for collecting samples for measuring chlorine residuals (or other necessary measurements, including those pertaining to other types of treatments). In general, a separation distance of at least 10 ft. (3.0 m) should be maintained between the point at which chlorine (or any other treatment) is applied to the discharge piping and the location of the downstream sampling tap to ensure complete mixing prior to sampling. However, a greater separation distance or a post-application static mixer may be required depending on the degree of mixing in the pipe at and downstream of the point of application.

The piping layout in most well houses does not provide a separation distance of at least 10 ft. (3.0 m), therefore, the downstream sampling tap may have to be located beyond the foot print of the well house and its associated sampling line extended back into the well house in order to ensure complete mixing prior to sampling. Alternatively, a static mixer may be located between the point where the chlorine (or any other treatment) is applied and the location of the downstream sampling tap to ensure complete mixing prior to sampling.

When the discharges of two or more wells are combined into a common header pipe prior to treatment at a central location, their respective upstream sampling valves shall be upstream of the points where their respective well discharge piping connects to the common header pipe and upstream of any treatment provided.

It is desirable to provide a valve in the sampling line between the wellhead piping and the sampling tap or hose bib so that the tap (or hose bib) can be repaired or replaced without depressurizing any portion of the system.

- 5) Chemical Injection – All points of chemical addition shall be no earlier than downstream of the check valve, and preferably after the flow meter and other appurtenances to both prevent direct feed of chemicals to a well and to minimize corrosion of the flow meter and other chemical sensitive appurtenances. The use of in-line static mixers is encouraged to ensure adequate mixing prior to sampling.

5. CONSTRUCTION CRITERIA FOR PITLESS UNITS AND RELATED APPURTENANCES

- a. **APPROVAL CRITERIA** – The use of pitless units for public water supply wells for below ground discharge is approved. Pitless “adapters,” those devices utilized in conjunction with a modification to the wall of the well casing (e.g., a hole) for the purpose of providing a connection between the discharge pipe and the well casing, are not approved for this purpose. A pitless unit is designed and shop-manufactured to be a complete unit that can only be attached to the top of the well casing to form a continuous, unbroken extension of the casing to at least 1 ft. (0.3 m) above the finished ground surface. The connection shall be at an elevation that is below the frost line.

The pitless unit may be for either submersible pumps or for deep well type turbine pumps and must permit the pumps to be readily removed. The pitless unit material of construction shall be compatible with the casing. The inside diameter of the pitless unit should be equal to that of the casing up to and including a diameter of 1 ft. (0.3 m) to facilitate making repairs to the well, pump, or well screen. KDHE approval is required for any connection where the diameter of the pitless unit differs from that of the casing. The drop pipe shall be attached by a threaded fitting at an elevation that is below the frost line.

- b. **LIMITATIONS ON FIELD WELDING** – If the connection to the casing is to be an in-the-field weld, the shop-manufactured and assembled pitless unit must be designed specifically for this method of connecting the pitless unit to the top of the well casing pipe. The only field welding permitted will be that which is needed to connect a pitless unit to the top of the well casing pipe with the resultant weld being a continuous, watertight weld.
- c. **CONCRETE SLAB** – In lieu of a well house, a reinforced concrete slab not less than 4 inches (10.2 cm) in thickness and extending 3 ft. (0.9 m) beyond the well bore in all directions shall be provided. The slab shall form a watertight joint with the pitless unit. The slab should preferably be placed at the ground finish grade, 1.5 ft. (46 cm) minimum above the natural ground, and shall slope away from the casing. The concrete slab shall be designed and constructed to withstand alternating freezing and thawing conditions. Approval may be given for placement of the slab below the pitless unit and below ground level. Where a pitless unit is used, a protective railing or steel posts shall be provided in such a manner that the pitless unit will not be damaged by machinery or farm animals. Appurtenances such as meter pits, frost free valves, etc., may be integral to the slab so long as they are located at least 3 ft. (0.9 m) beyond the outer diameter of the well bore and are appropriately curbed and drained.

d. APPURTENANCES

- 1) Check Valve – There shall be at least one check valve within the well casing. Check valves for these types of wells are typically located in a spool piece which is utilized to join the pitless unit and the casing, the drop pipe, or integral to the submersible pump.
- 2) Sanitary Well Seal – The top of the pitless unit shall be securely fitted with a sanitary well seal, which creates an air and watertight seal. The pitless unit shall also be designed to receive a contamination-proof conduit for power purposes.
- 3) Well Vent – The pitless unit shall be fitted with a vent, which shall terminate in a full 180° return bend. The elevation of the well vent shall be not less than 2 ft. (0.6 m) above the 100-year flood level. If this level is not known, then the required vent elevation is at least 2 ft. (0.6 m) above the highest known flood level. The opening in the vent shall be screened with 16-mesh non-corrodible screen.
- 4) Water Level Measurement – Provisions shall be made for the periodic measurement of water levels in the completed well in accordance with the requirements established by DWR in KAR 5-6-13 (DWR, 1999). Tubes or cables, required for measurement of water levels, shall be installed through special fittings in the watertight cap in a manner to prevent the entrance of surface water or other contaminants within the well casing.
- 5) Meters – Each well must be provided with a meter and it shall meet the requirements established by DWR in KAR 5-1-4 et seq. (DWR, 2004). Meter boxes or vaults should be constructed with crushed rock bottoms (French drains) to permit adequate drainage, and located and covered so as to minimize the entrance of surface water. A shut-off valve to isolate the meter to facilitate testing and repairs or replacement should be located downstream from the meter. Meter pits, boxes or vaults integral to a pitless unit's surface slab shall be located at least 3 ft. (0.9 m) beyond the outer diameter of the well bore and be appropriately curbed and drained.
- 6) Sampling Taps – The well's design shall include a sampling tap to collect raw water samples from the well or its discharge piping upstream of where chlorine (or any other treatment) is applied to the well's discharge piping. The design shall also include a sampling tap downstream of where chlorine (or any other treatment) is applied to the well's discharge piping for the purpose of collecting samples for measuring chlorine residuals (or other necessary measurements,

including those pertaining to other types of treatments). As outlined above in Section D, Subsection 4.G.4, a separation distance of at least 10 ft. (3.0 m) should be maintained between the point at which chlorine (or any other treatment) is applied to the discharge piping and the location of the downstream sampling tap to ensure complete mixing prior to sampling. However, a greater separation distance or a post-application static mixer may be required depending on the degree of mixing in the pipe at and downstream of the point of application.

When the discharges of two or more wells are combined into a common header pipe prior to treatment at a central location, their respective upstream sampling valves shall also be upstream of both where their respective well discharge piping connects to the common header pipe and where any treatment is applied to the combined flow in the header pipe.

It is desirable to provide a valve in the sampling line between the wellhead piping and the sampling tap or hose bib so that the sampling tap (or hose bib) can be repaired or replaced without depressurizing any portion of the system.

Sampling appurtenances such as meter pits, vaults, frost free valves, etc., integral to a pitless unit's surface slab shall be located at least 3 ft. (0.9 m) beyond the outer diameter of the well bore hole and be appropriately curbed and drained.